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Reduction of Pollutant from Grey Water Using Modified Hydraulic Structure Case Study: Multi – Layer Cascade Weir

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Abstract

The aim of this study is to propose a modified treatment system to remove and reduce the contamination of pollutants found in grey water. A combination of stepped cascade weir and spray aerator which consist of two layers of stepped cascade weir, suspension growth unit, and clarification tank. An experimental system to treat grey water has been constructed during 8 months. The performance of the treatment schemes has been evaluated by monitoring the quality of the raw grey water and effluent for some parameters, which are: Chloride Cl^-, Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD_5), Iron Fe^{+2}, and Manganese Mn^{+2}**.** The removal efficiencies for grey water pollutants COD, and BOD_5 organic loading was measured which ranged between (51 % to 53 %), while the reduction of Fe^{+2}, Mn^{+2}, and Cl^- were (11 %- 23%), (12 %-26 %), and (16 %-24 %) respectively.

Keywords: grey water, multi-layer cascade weir.

1- Introduction

Grey water is the wastewater generated from kitchens, laundries and bathrooms, while black water, is waste containing human excrement. Grey water if treated appropriately, can be considered a resource used on-site for garden and lawn irrigation, toilet flushing, washing machines, and other outdoor uses. A grey water amount that is generated will vary depending on the number of people, their age, their water usage pattern and time **[1, 2].**

Treatment systems for grey water exist in many forms, varying in their complexity, treatment method, and location within or outside the home, and should be designed in accordance with grey water source, quality, site specifications, and reuse patterns. Grey water treatment systems range in sophistication from simple branched-drain garden irrigation networks to full tertiary treatment systems that can filter water to nearly potable levels of quality **[3].**

Hydraulic structures, such as stepped cascades and weirs, involve air entrainment _aeration_ and oxygen transfer; therefore, it can be increased dissolved oxygen levels. Weir aeration occurs in rivers, fish hatcheries, and wastewater treatment plants. A stepped cascade aerator is another type of aeration structure **[4].**

A cascade aerator consists of a series of steps that the water flows over. In all cascade aerators, aeration is accomplished in the splash zones. The aeration action is similar to the flowing stream **[5]**.

In the gravity aeration of wastewater, the aeration process brings wastewater and air into close contact by exposing drops or thin sheets of wastewater to the air. Oxygen diffuses from the air into the wastewater and helps to increase the Dissolved oxygen content of the wastewater **[6].** The efficiency of the natural aeration process depends almost entirely on the amount of contact surface between the air and wastewater **[7].** This contact is controlled primarily by the size of the wastewater drop or air bubble. In addition; the efficiency of the natural aeration process depends on the geometry shape of natural aeration type, material properties and flow conditions **[6, 7].**

The basic goal of this research is to modify the grey water treatment using combination of stepped cascade weir with spray aerator, and evaluate experimentally its performance.

2- Materials and Methodology

The experiments were carried out using synthetic grey water taken from bath and kitchen. Daily measurement for different initial concentration and constant flow rate was achieved in this set of experiments. The experiments were performed with a constant flow rate of 0.4 m^3/hr. Natural aeration was done by means of spraying the water and running it over surfaces and spray aerators consisting of a series of horizontal cascade rectangular basins which water is distributed and made to fall into a collection tank at the end of the stepped cascade weir. The laboratory model is shown in Figure (2), which consists of different parts as follows:

1- The first stage is primary sedimentation tanks which consists of two PVC tanks (42*42*80 cm) of (120) L.

2- The second stage is two layers stepped cascade weir, the upper layer consist of three steps manufactured from aluminum of dimensions (36 cm *42 cm *80 cm), each step where perforated into 36 holes (10 mm), while the lower layer consists of three steps manufactured from granite of dimensions (45 cm *30 cm *30 cm), (30 cm *30 cm *30 cm), and (20 cm *30 cm *30 cm) respectively, three rectangular weirs of dimensions (40 cm *30 cm), (25 cm *30 cm), (15 cm *30 cm) respectively

3- The third stage is Clarification tanks which consist of two PVC tanks one for receiving outlet and one for recycling treated water.

4- Two submerged pump of maximum head (3.7 m) and maximum flow rate (3.75 m^3/hr), the first is on the primary tank for pumping grey water, and the other is on the recycling tank for recycling treated grey water.

5- Flow meter ranges between (0.4-4 m^3/hr.) is used to measured and controlled flow rate by global valve.

The arrangement and schematic of the lab scale model is shown in Figure (1). The general arrangement of laboratory unit and the arrangement of Cascade basins and spray positions are shown in the figures (2 and 3).

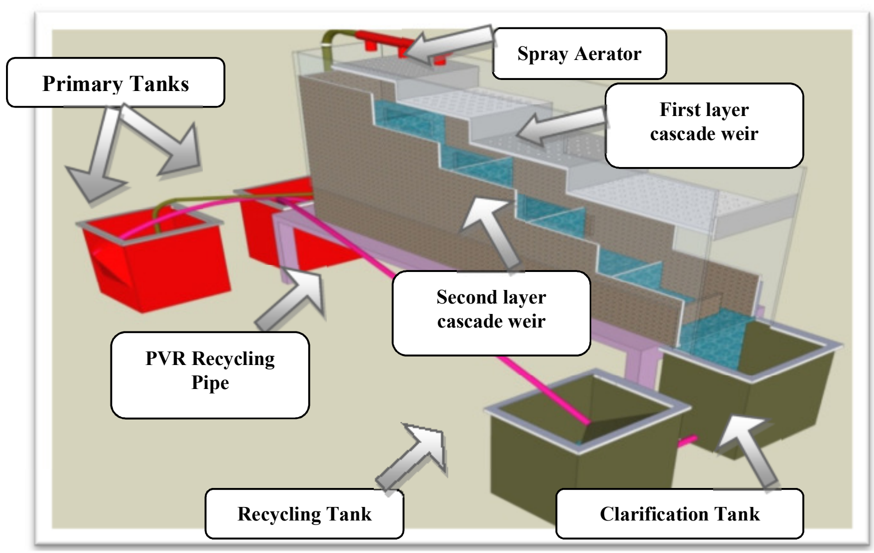

Figure1: Schematic representation of lab-scale unit.

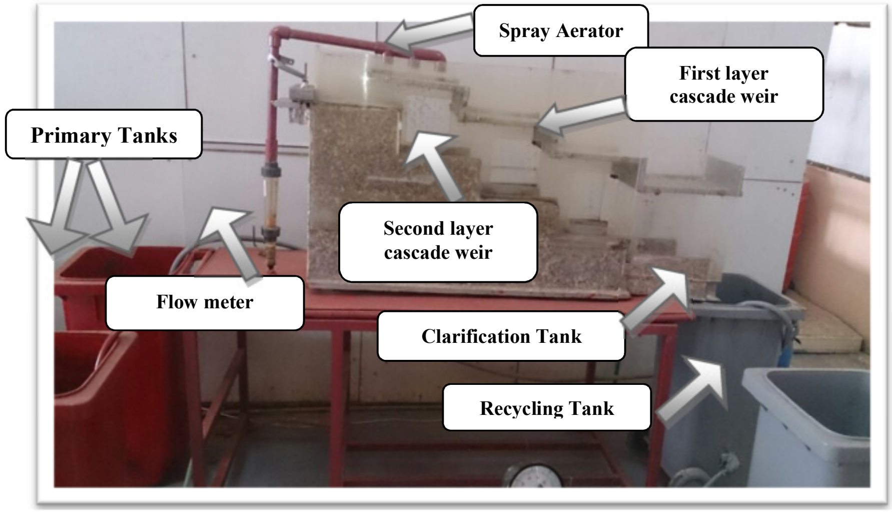

Figure 2: General arrangement of laboratory unit.

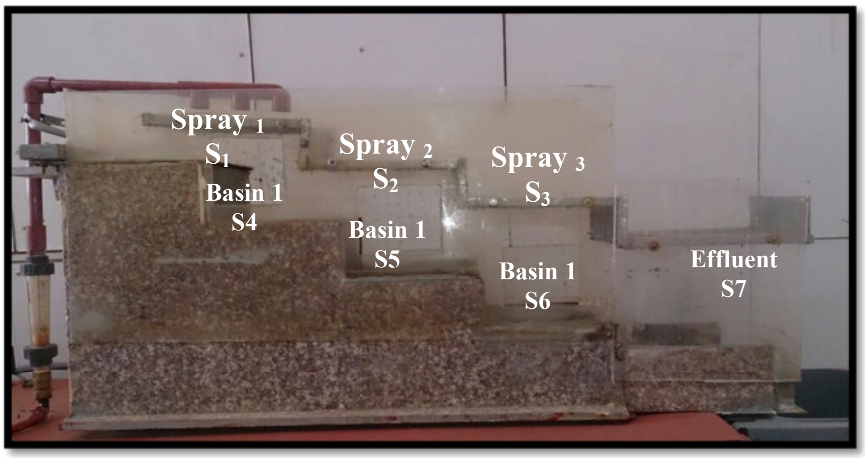

Figure 3: Arrangement of cascade basins and spray positions

Samples were taken from the (Inlet tank, after spray aerator, after mixing basins, and effluent) as shown in figure (3) to test the quality of the marginal water used during the experiment periodically. These samples were analyzed by standard at (10) method for water and wastewater analysis in environmental fluid laboratory. The measurements included:, chemical oxygen demand (COD), Biological Oxygen demand (BOD_5), Chlorine (Cl^-), Manganese (Mn^{+2}), and Iron (Fe^{+2}) contained in grey water were achieved for each samples.

3- Results and discussions

The removal efficiency for the grey water pollutants was evaluated along the period of study. The system using combination of cascade aeration and spray aerator, the system was monitored to characterize the grey water quality parameters efficiencies during 8 months.

The initial COD and BOD_5 organic loading of raw influent were ranged between (48 - 87 Kg/m^3/day), (31-57 Kg/m^3/day), while the initial concentrations for Mn^{+2}, Fe^{+2}, and Cl^- were ranged between (5.3 mg/l-12.9mg/l), and (99 mg/l-214.3mg/l), and (1.5 mg/l -2.46 mg/l) respectively.

The experimental results show that removal rate of COD, BOD_5 was (34 %-51%), (44%-53%) respectively, this confirms to **(Abbood et al, 2013)** which used a combination of cascade aeration and biofiltration systems to reduce some pollutants from grey water; they reported that the major role of aeration was controlled the COD, TSS, and TDS, and the average removal rate of COD was more than 60%, as shown in figure (4 and 5) .Figure (6 and 7) show the average removal efficiency of raw grey water for Mn^{+2}, and Fe^{+2} are (11%-23%), (12 %-26%).

Figure 8 show the removal rate of Cl^- which is ranged between (16%-24%) which is less than the removal efficiency obtained by **(Abbood et al, 2013)** which reported that the removal efficiency of Cl^- (27 %-61%) due to the addition of bio-filtration process.

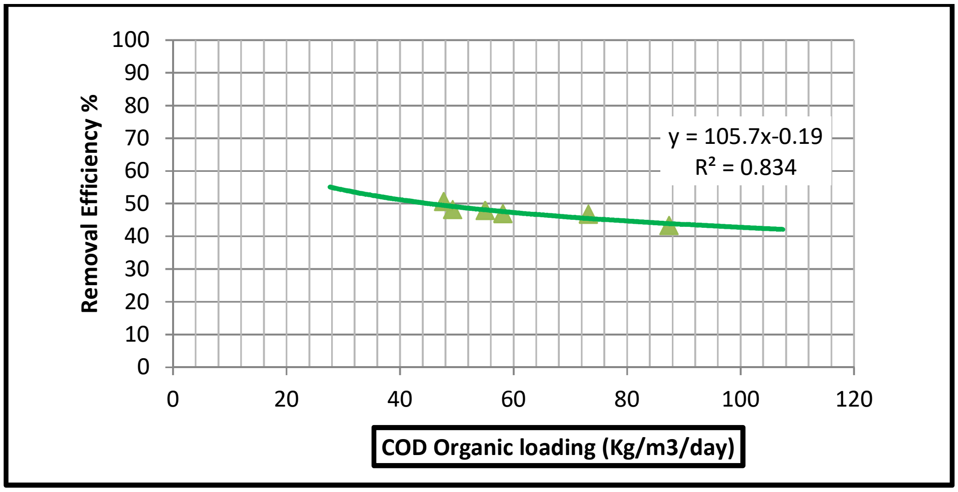

Figure 4: Reduction of different COD organic loading.

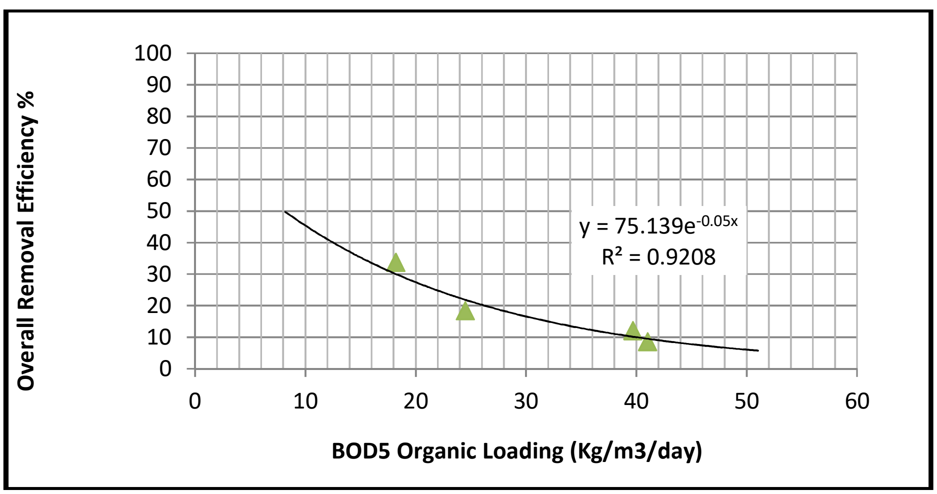

Figure 5: Reduction efficiency for different initial BOD5 organic loading.

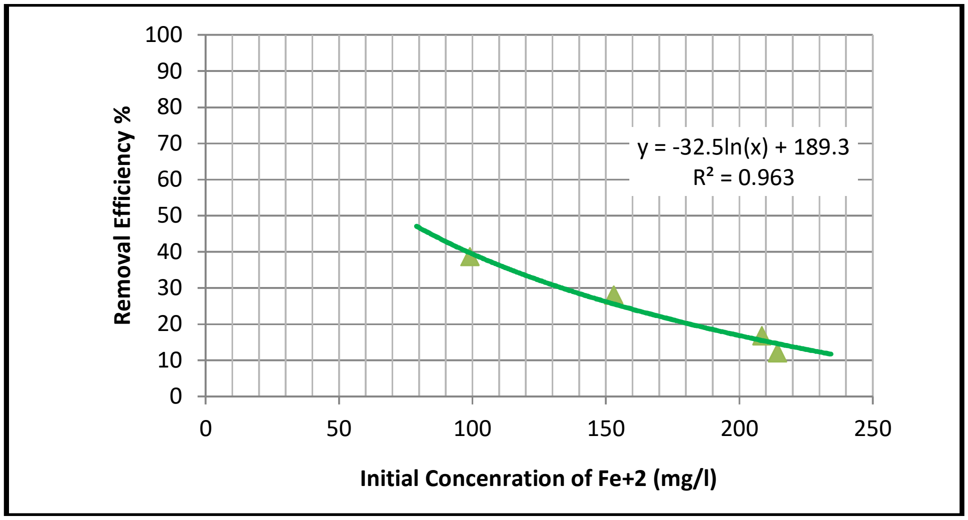

Figure 6: Fe^{+2} Removal efficiencies for different initial concentrations.

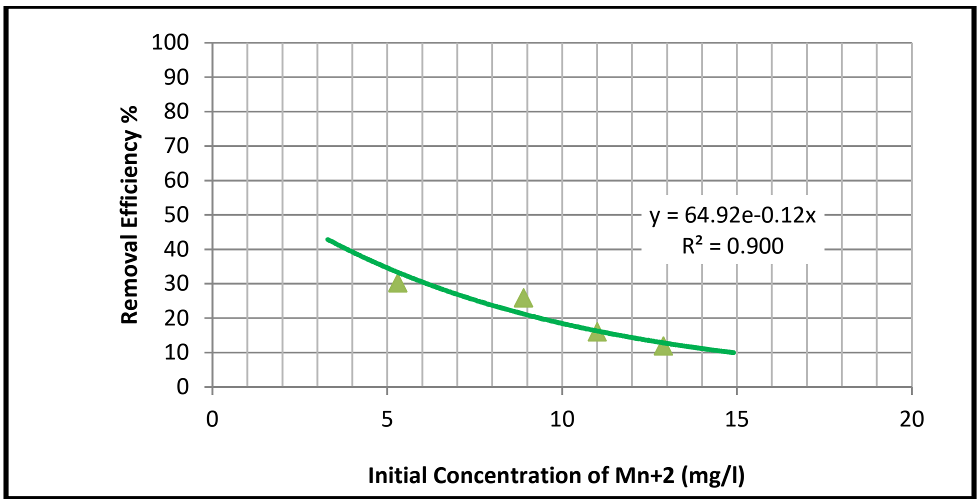

Figure 7: Mn^{+2} Removal efficiencies for different initial concentrations

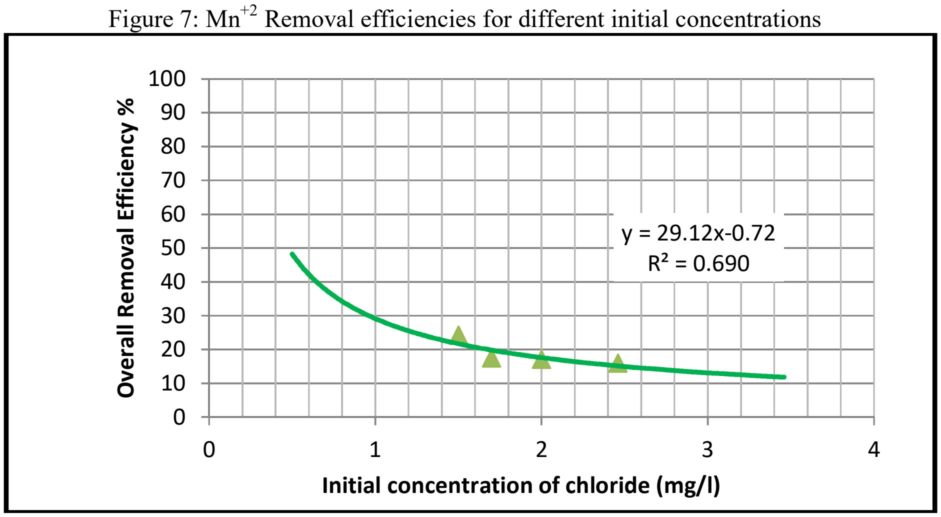

Figure 8: Removal efficiency for different initial concentrations of chloride

4- Conclusions

The conclusions which are drawn from the study can be summarized as follows:

1- The experiments were conducted for constant flow (0.4 m^3/hr) for 4 hours run time

2- The initial organic loading of COD and BOD_5 of raw influent were ranged between (48 - 87 Kg/m^3/day), and (31-57 Kg/m^3/day) respectively.

3- The initial concentration of Mn^{+2}, Fe^{+2}, and Cl^- were (5.3 mg/l-12.9mg/l), and (99 mg/l-214.3mg/l), and (1.5 mg/l -2.46 mg/l) respectively.

4- The removal efficiencies of COD and BOD_5 organic loading are (51%, and 53%)

5- The reduction rate of Fe^{+2}, Mn^{+2}, and Cl^- were 23%, 26 %, and 24 % respectively.

6- The initial concentration of the pollutant measured affects the removal efficiency, that is when the initial concentration increases the removal efficiency will decrease.

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